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US 5251078 A
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INT CL^6 G01S
Online: WPI

(54) **Monitoring vehicle position**

(57) A vehicle monitoring apparatus comprises a GPS receiver 400, micro controller 403, a plurality of sensors and actuators 407, a memory 402, a radio transmitter 405 and a data communication antennae 406. The apparatus measures the vehicle's position every minute; the first position is stored in full, then subsequent positions are stored relative to the first position, other data may be stored as well.

Every hour the whole contents of the memory is transmitted to a monitoring station.

This procedure reduces the amount of data to be transmitted.

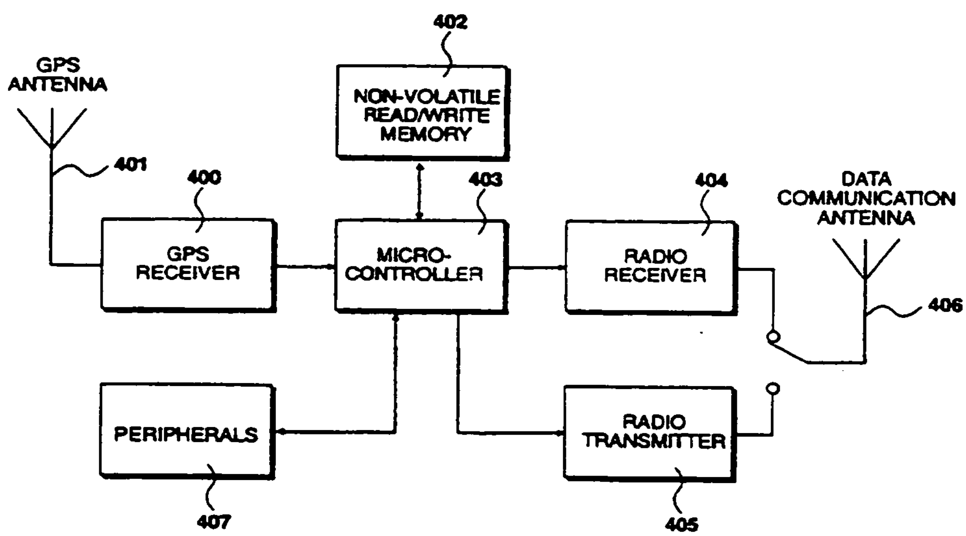

Figure 4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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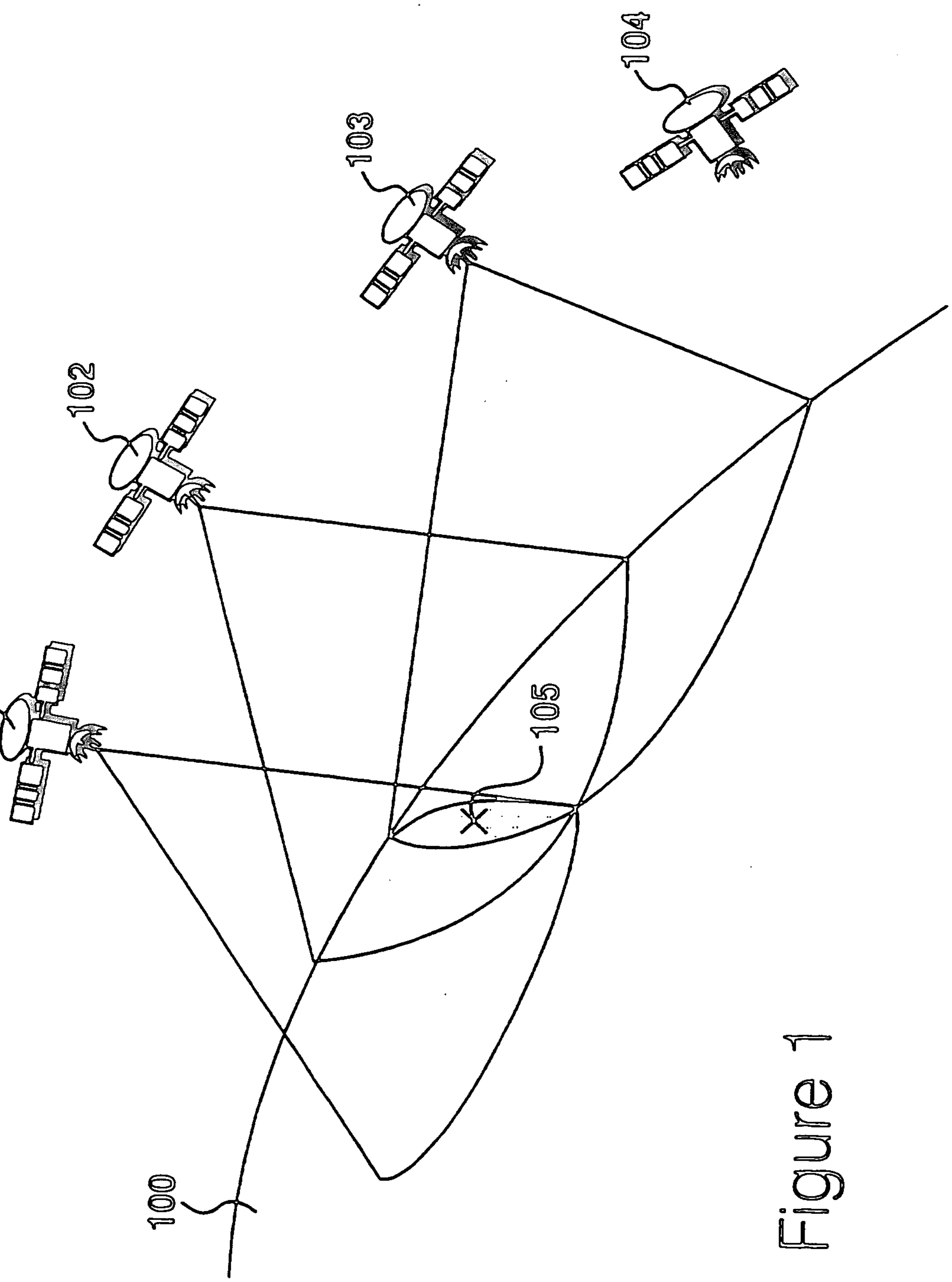
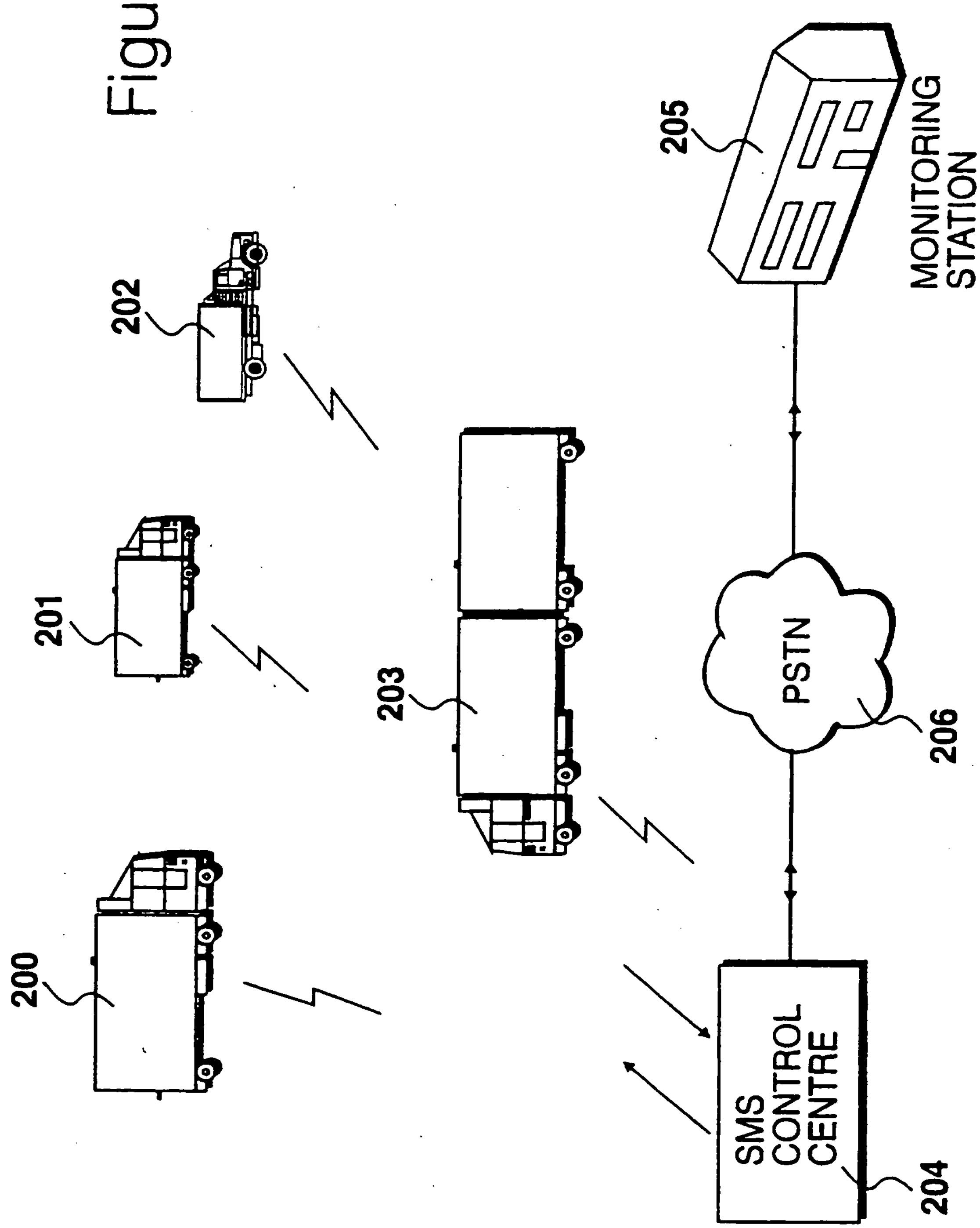


Figure 1

Figure 2


200
201
202
203
SMS
CONTROL
CENTRE
204
PSTN
206
205
MONITORING
STATION

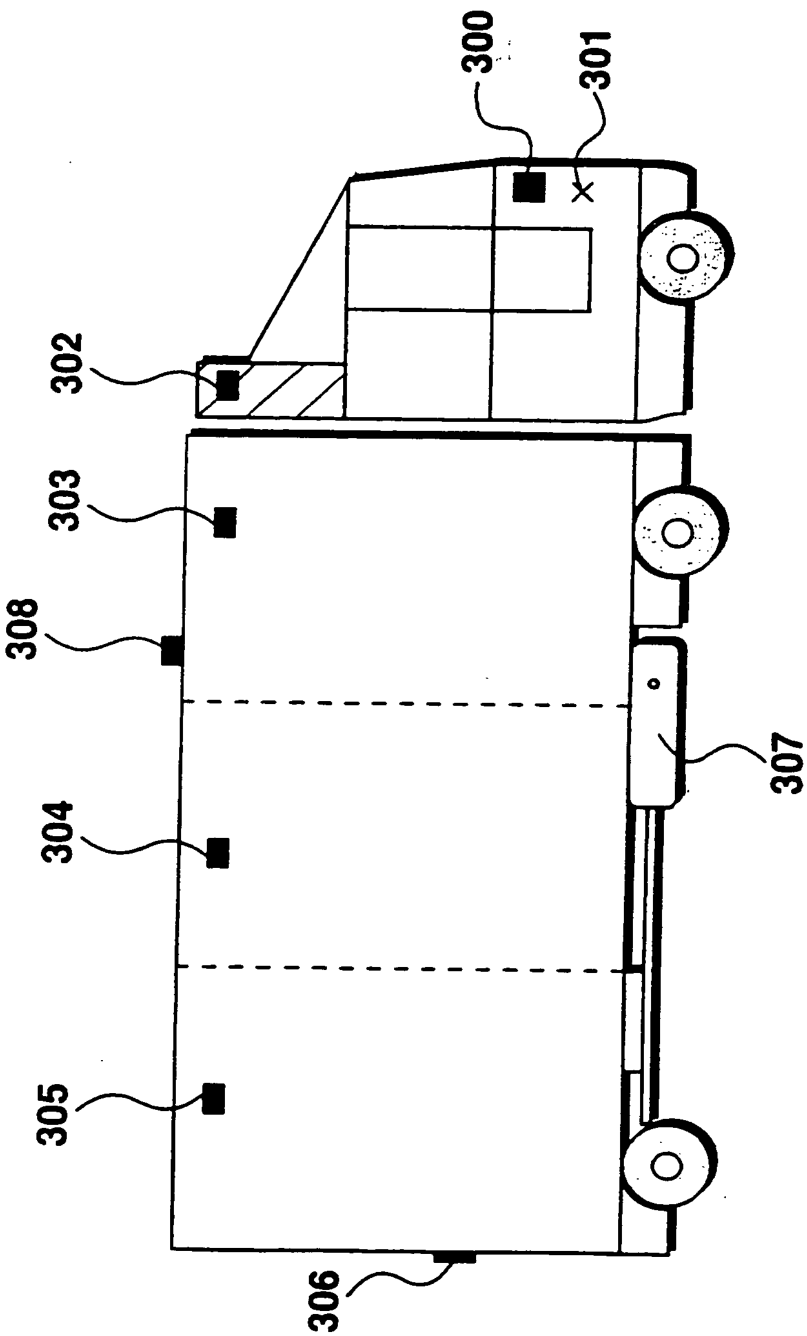


Figure 3

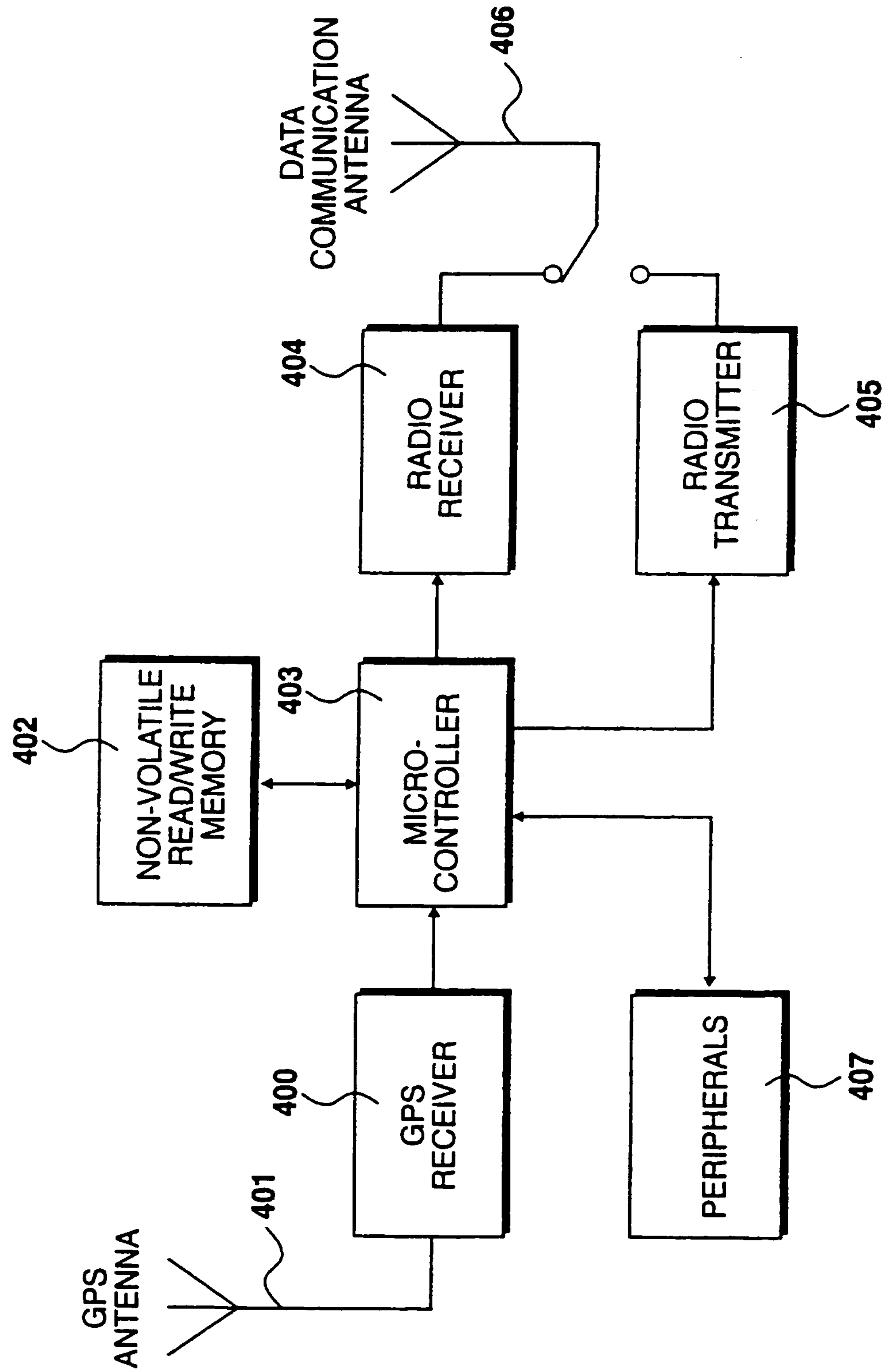
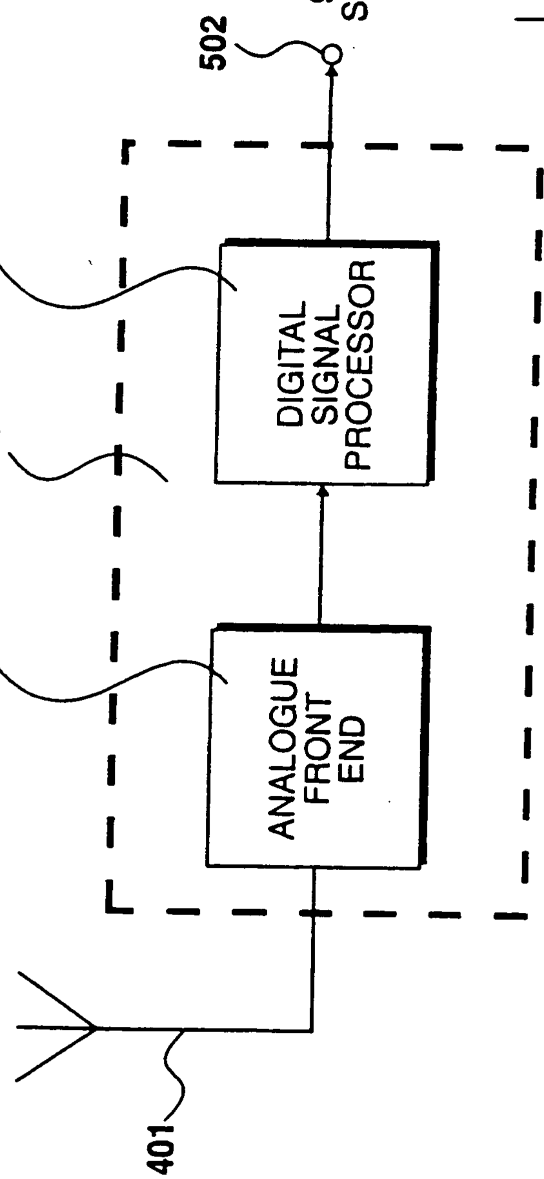
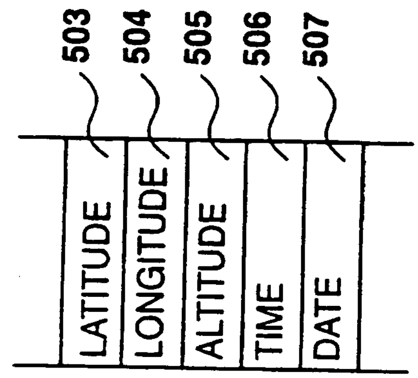

DATA COMMUNICATION ANTENNA
406
RADIO RECEIVER
404
RADIO TRANSMITTER
405
NON-VOLATILE READ/WRITE MEMORY
402
MICRO-CONTROLLER
403
GPS RECEIVER
400
PERIPHERALS
407
GPS ANTENNA
401

Figure 4



500
501
400
401
502
ANALOGUE FRONT END
DIGITAL SIGNAL PROCESSOR
9600 BAUD SERIAL DATA



503
504
505
506
507
LATITUDE
LONGITUDE
ALTITUDE
TIME
DATE

Figure 5

		23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
601	DATE	0	0	0	0	0	0	1	D	D	D	D	D	M	M	M	M	Y	Y	Y	Y	Y	Y	Y	Y
602	START TIME	0	0	0	0	0	1	1	H	H	H	H	H	M	M	M	M	M	M	S	S	S	S	S	S
603	STOP TIME	0	0	0	0	0	1	0	H	H	H	H	H	M	M	M	M	M	M	S	S	S	S	S	S
604	ABSOLUTE LATITUDE	1	0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
605	ABSOLUTE LONGITUDE	1	1	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
606	RELATIVE LAT/ LONG	0	1	T	T	T	T	T	T	T	T	T	T	T	G	G	G	G	G	G	G	G	G	G	G

607

Figure 6

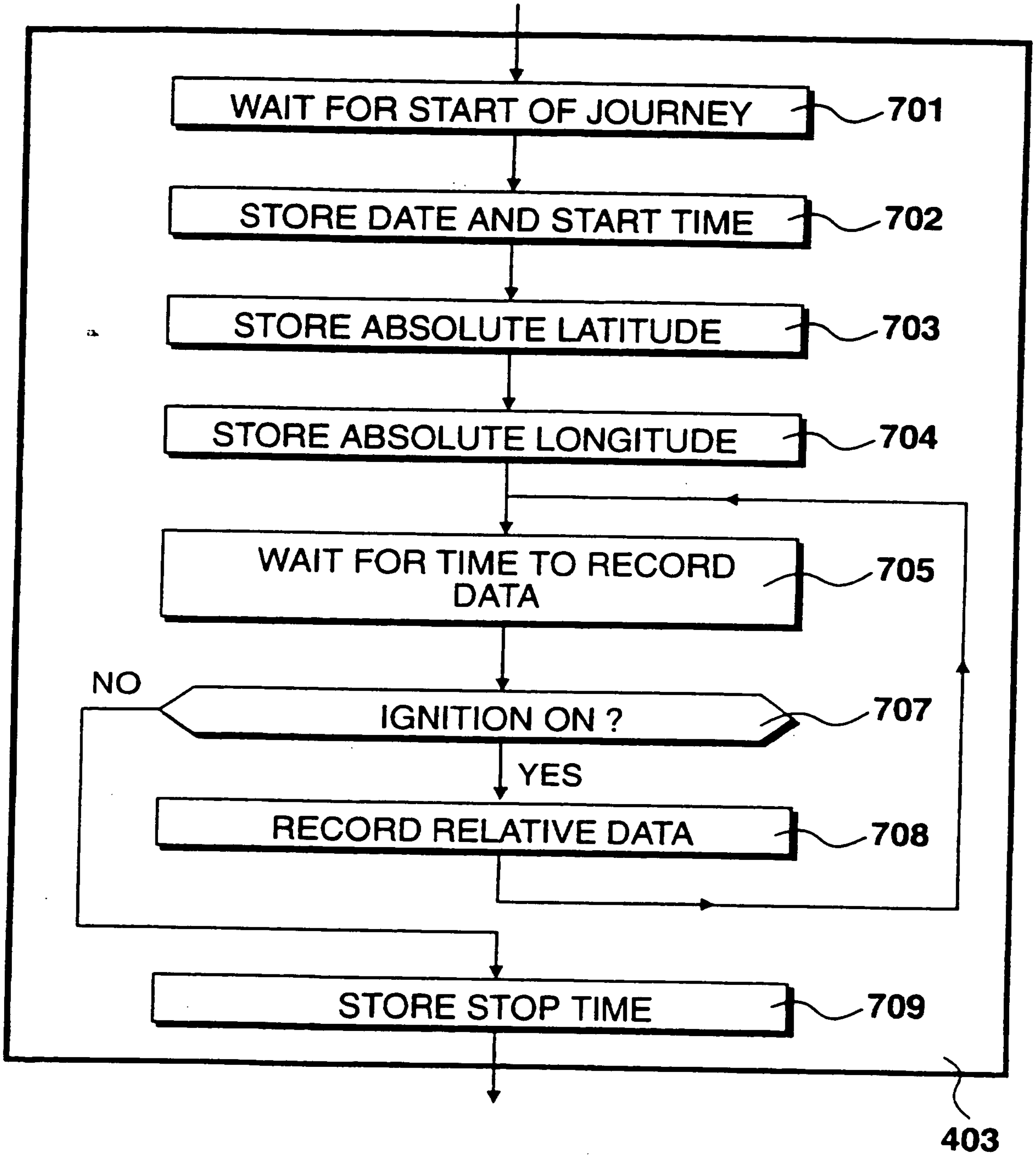

WAIT FOR START OF JOURNEY
701
STORE DATE AND START TIME
702
STORE ABSOLUTE LATITUDE
703
STORE ABSOLUTE LONGITUDE
704
WAIT FOR TIME TO RECORD DATA
705
NO
IGNITION ON ?
707
YES
RECORD RELATIVE DATA
708
STORE STOP TIME
709
403

Figure 7

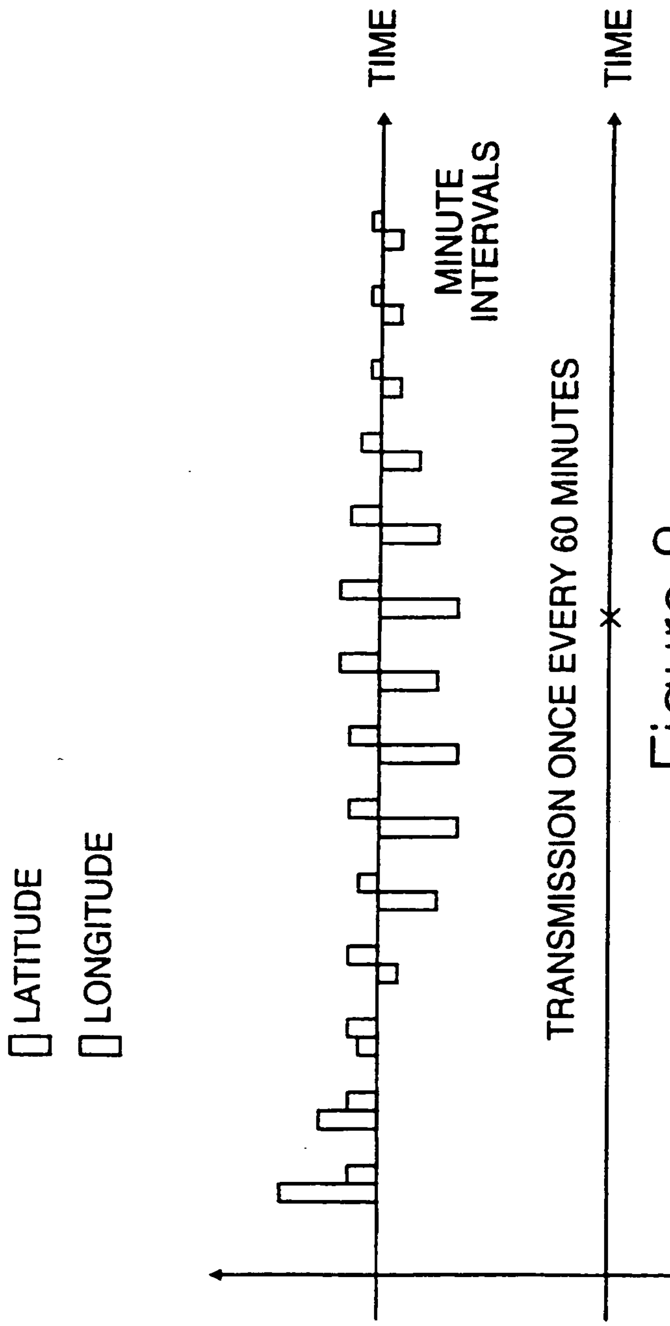

LATITUDE
LONGITUDE
TIME
MINUTE INTERVALS
TRANSMISSION ONCE EVERY 60 MINUTES
TIME

Figure 8

PERIODIC STIMULI	APERIODIC STIMULI
GPS SERIAL DATA (1 Hz)	IGNITION
TEMPERATURE SENSORS (1 Hz)	ALARM CONDITIONS:
	TEMPERATURE
VEHICLE SPEED (1 Hz)	PETROL
	DOOR OPENING

Figure 9

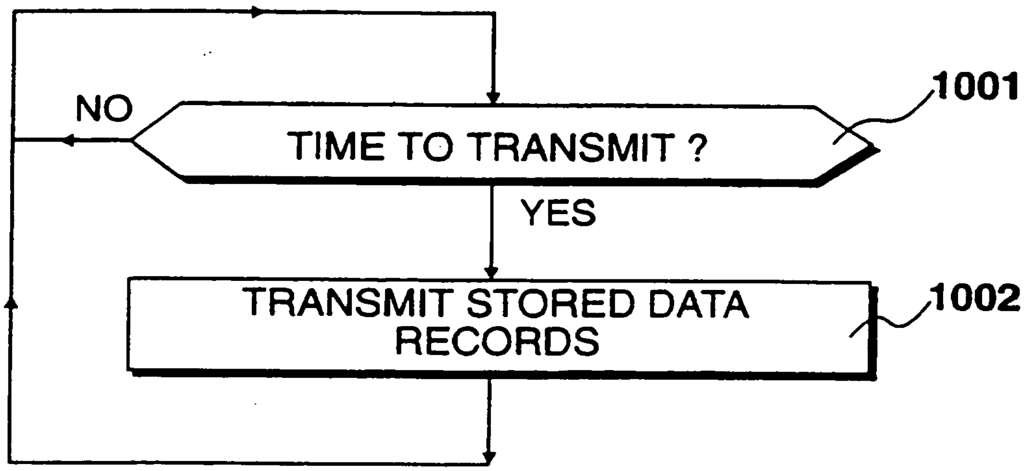


Figure 10

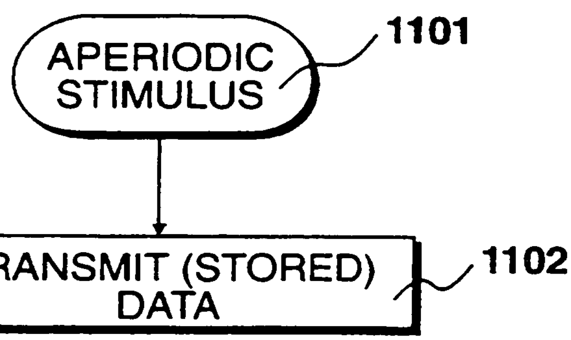


Figure 11

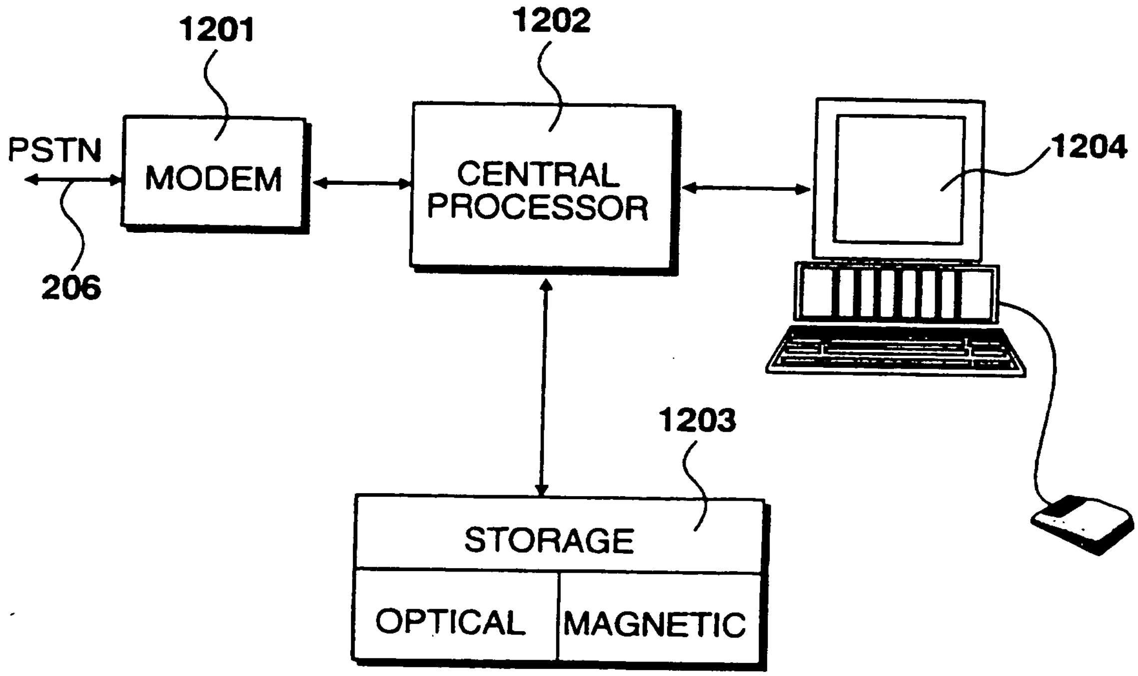

1201
1202
PSTN
MODEM
CENTRAL PROCESSOR
1204
206
1203
STORAGE
OPTICAL
MAGNETIC

Figure 12

2318940

Monitoring Vehicle Positions

A method and apparatus for monitoring the position of a vehicle or group of vehicles.

Introduction

Global positioning systems (GPS) are known in which a plurality of satellites in earth orbit are arranged to transmit signals such that a receiver located on the earth's surface is able, by triangulation techniques, to identify its location. Advances in such systems has resulted in them being included in small and relatively low cost equipment. As a result such technology is now in wide spread use in diverse equipment, for example for identification of the position of one or more vehicles.

GB 2288892 describes a system in which the position of a road vehicle is monitored by transmitting GPS positional data from a GPS system located on the vehicle to a base station. The data is transmitted using a radio link or GSM data link. Data is transmitted at closely spaced regular intervals so as to provide substantially real-time tracking of the vehicle.

With the system described in GB 2288892, in order to enable a remote monitoring station to obtain such real-time tracking data, the interval between successive transmission events must be relatively short. Thus, a communication channel may be continuously kept open, tying up the channel, or opened and closed at short intervals, in which case the transmission time overhead of the protocol exchanges in creating the channel is significant in relation to the actual transmission time required for transmission of positional data. Such substantially constant use of a communications channel is expensive and can be inefficient e.g. in areas of poor reception.

Summary of the Invention

According to a first aspect of the present invention there is provided

a method of monitoring a geographically moveable object comprising the steps of;

substantially continuously receiving geographic position data at said geographically moveable object;

recording a first set of data representing the absolute geographic position of said object at a first position; and

recording a second set of position data representing a second position of said object relative to said first position.

Preferably the method comprises the step of recording subsequent sets of relative position data representing subsequent positions of said object relative to the immediately preceding recorded position.

In a preferred embodiment, the said absolute position data comprises two n-bit words and said relative position data comprises a one n-bit word.

In another preferred embodiment there is provided a method further comprising the step of transmitting said recorded data to a base station to provide a history of the movement of said object at said base station.

The features of further preferred embodiments are as set out in claims 4 to 12 and 14 to 21.

In a second aspect of the present invention there is provided an apparatus for monitoring a geographically moveable object comprising;

means for substantially continuously receiving geographic position data at said geographically moveable object;

means for recording a first set of data representing the absolute geographic position of said object at a first position; and

means for recording a second set of position data representing a second position of said object relative to said first position.

Preferably the apparatus comprises means for recording subsequent sets of relative position data representing subsequent positions of said object relative to the immediately preceding recorded position.

In a preferred embodiment, the absolute position data comprises two n-bit words and said relative position data comprises a one n-bit word.

In another preferred embodiment there is provided a apparatus operable to transmit said recorded data to a base station to provide a history of the movement of said object at said base station.

The features of further preferred embodiments are as set out in claims 25 to 33 and 35 to 42.

Storage of the position data at the movable object reduces the need to maintain substantially constant communication with a base station while allowing a history of the vehicle position to be established. Also, the storage of the data in a compact manner reduces the memory requirements of the equipment at the moveable object while also reducing the time for the eventual downloading the recorded data to a base station.

Brief Description of the Drawings

Referring to the drawings herein;

Figure 1 illustrates a plurality of global positioning satellites in orbit around the earth;

Figure 2 illustrates a plurality of moveable vehicles and an overview of a monitoring apparatus for monitoring the vehicles according to a preferred embodiment and method of the present invention;

Figure 3 illustrates a vehicle fitted with a data collection unit and associated sensors and actuators comprising the preferred embodiment;

Figure 4 illustrates an arrangement of the data collection unit of Figure 3;

Figure 5 illustrates a GPS receiver comprising the data collection unit of Figure 3;

Figure 6 illustrates the format of data accumulated by the data collection shown in Figure 3;

Figure 7 details the data collection method identified in Figure 6, configured to store data using the format identified in Figure 7;

Figure 8 illustrates transmission of positional signals in accordance with a preferred embodiment of the present invention;

Figure 9 lists a selection of stimuli initiating processes of the preferred method;

Figure 10 illustrates further operations of the data collection unit;

Figure 11 illustrates an operation of the data collection unit in response to an aperiodic stimulus; and

Figure 12 illustrates a remote monitoring station apparatus according to the preferred embodiment of the present invention.

Detailed Description of a Preferred Embodiment

A preferred embodiment and method according to the invention will now be described by way of example only with reference to the accompanying drawings identified above.

Figure 1 illustrates a section of the earth's surface 100, around which are continuously orbiting 24 operational satellites including 3 spare satellites of the Navstar type space based radio navigation system satellites developed by the US Department of Defence. The satellites are placed in six orbital planes at a distance of around 20,200 kilometres above the earth's surface. The satellites orbit with a 12 hour orbital period and an inclination angle of 55°. Each satellite continuously broadcasts an RF signal at a centre frequency of 1575.42 MHz (L1 Band). The RF signal is modulated by a 10.23 MHz clock rate precise ranging signal, and by a 1.023 MHz clock rate coarse acquisition code ranging signal. At any one time at a position 105 on the surface of the earth, a minimum of 5 satellites are in line of sight view.

At the point 105 on the earth's surface, provided there are at least three satellites within direct line of sight and therefore it is possible for a GPS receiver equipment positioned at that point 105 to calculate the

precise geographical position of the point 105 by means of the RF signals transmitted by the satellites.

Referring to Figure 2 there is shown a plurality of moveable objects, for example trucks 200-203 travelling over the earth's surface, and a monitoring apparatus comprising a base station 204 for receiving signals transmitted from the moveable objects 200-203, and a monitoring station 205 in communication with the base station 204 over the public switched telephone network 206.

Each truck communicates with the base station 204 via a radio link. The monitoring station 205 is in communication with the base station 204 over the PSTN 206 for sending signals from the monitoring station for transmission by the base station 204, and for communicating radio signals received by the base station 204 back to the monitoring station 205.

Referring to Figure 3 herein, there is shown a truck fitted with items of monitoring apparatus according to the preferred embodiment of the present invention. Monitoring apparatus fitted to the truck comprises a data collection unit 300, a plurality of sensors 301-307 for sensing operations of the truck, the sensors connected to the data collection unit 300; and a radio receiver 308.

The sensors positioned around the truck may sense operations of the truck such as fuel level; opening and closing of vehicle body doors; operation of a vehicle refrigeration unit; temperature within individual compartments of a vehicle body; engine oil temperature; oil pressure; tachograph readings; tyre pressure; odometer readings.

There may also be provided one or more actuators controlled by the data collection unit 300, for example an engine immobiliser unit, or an alarm unit actuator (not shown).

Referring to Figure 4 a data collection unit 300 comprising a GPS receiver 400 connected to an antennae 401; a non volatile read-write memory 402, a micro controller 403, a radio receiver 404 and radio transmitter 405 connected to a data communication antennae 406; the

micro controller being connected to a plurality of peripherals 407 comprising the aforementioned sensors and actuators (not shown).

Referring to Figure 5, the GPS receiver 400 comprises an analogue front end amplification section 500 capable of receiving signals from 12 satellites simultaneously, and a digital signal processor 501 receiving signals from the analogue front end amplifier and outputting a serial data stream at 9,600 baud rate, from output 502 the serial data including geographical positional data in terms of latitude, longitude and altitude co-ordinates, and time and date data 503-507 respectively.

Referring to Figures 4 and 5, the micro controller 403 continually receives the position and time data from the GPS receiver 400 as the truck travels and parks and periodically stores the position and time data in the memory 402 at predetermined intervals. Sensor data from each of the sensors on the truck is available to the micro controller 403 either continuously, or in response to poll signals. In the preferred embodiment, the memory 402 comprises a 32 kilobyte non volatile read write memory for example a 62256 static RAM with low leakage reservoir capacitor. The micro controller in the preferred embodiment comprises an Intel 80C51 micro controller.

Position data comprising a latitude data and a longitude data, and time and date data is abstracted from the byte stream data produced at the output 502 of GPS receiver 400 by the micro controller 403. The micro controller 403 has a set of registers into which the position and time data is written once every second. The set of registers always contains the most recent position and time/date data. The micro controller is configured in accordance with settable control instructions to log the current position and date/time data held in the registers, in the non volatile read write memory 402. The read write memory 402 accumulates a set of records, each comprising a position data and a corresponding time/date data. Each record, in addition to containing position and time/date data may also include data concerning other operational parameters of the vehicle, for example a fuel level data, an engine temperature data, door open/close

data, vehicle body temperature data, fridge operating/non-operating data or the like, as contained in signals received from the on-board sensors of the vehicle.

As mentioned above, the time interval between successive loggings of the position and time/date data in the memory 402 may be pre-set. In the preferred embodiment, data is stored at intervals of one minute, but the interval can be varied in the range for example 30 seconds to ten minutes, the period being selected so as to provide the required positional resolution of the tracking of the vehicle. Additionally, position data may be stored in the memory 402 in response to an aperiodically occurring event such as a sensor signal. In this case, a record of the sensor signal along with the appropriate position and time data is stored in memory 402.

Positional data is logged in the memory 402 as 24-bit words. Each word represents a particular information type and a set of information types is illustrated in Figure 6. The information types comprise a date 601, a start time 602, a stop time 603, an absolute latitude 604, an absolute longitude 605 and a relative latitude and longitude combined into a single 24-bit word, 606. In the preferred embodiment, the altitude data contained in the GPS data is discarded.

A first grouping of bits represents the information type, with a second grouping representing the information itself and a division between these two groupings is illustrated by line 607. An absolute latitude 604 and an absolute longitude 605 require a total of 22-bits, represented as T bits and G bits respectively. An absolute longitude is identified by type code 10 and this distinguishes it from an absolute longitude having type code 11.

After an absolute longitude and an absolute latitude have been recorded, subsequent positional data is stored as a relative latitude and longitude, by subtracting the absolute values previously recorded from a present position. This provides a level of compression such that only 11-bits are required for the relative latitude with a further 11-bits being required for the relative longitude. A word of this type is identified by word type code 01.

Word type code 00 precedes the other three types of words which are then uniquely defined by lower significant bits 17 to 21. It can be appreciated that the provision of this number of bits for identifying word types allows other types of words to be recorded, which may be reserved for user-specific information. Thus, bits 17 and 18 are used to distinguish a date, a start time and a stop time, with bits 0 to 16 being used to convey the associated data.

As shown in figure 6, a typical data set would be initiated with the recording of the date. This would be followed by a start time which is then followed by an absolute latitude and an absolute longitude. While the vehicle remains in motion, relative values may be recorded and, under normal operating conditions, words of type 606 would constitute the bulk of the stored information, thereby obtaining maximum advantage from the compression provided by this word type. When the vehicle stops, the device would record a final absolute latitude and an absolute longitude and the data set would be terminated by a stop time and again the date. Thus, short journeys result in relatively small data sets with larger journeys producing larger data sets.

Although the data stream issuing from the GPS receiver 400 contains absolute geographical positional data in terms of data describing a full latitude and longitude co-ordinate, by storing difference data instead of absolute latitude and longitude positional data, the memory requirement for storing a record can be reduced. In addition, an absolute positional data may be stored in the memory in response to an aperiodic stimuli for example a signal issued by the truck ignition when the ignition is turned on, and used as a reference from which to determine absolute position data from the difference data.

The process according to the preferred embodiment by which the micro-controller governs the logging of data in the memory 402 is shown in figure 7 in which , at step 701, the micro-controller waits for a signal to indicate the start of a journey. This signal may be manually indicated e.g. by the driver operating a button or may be automatically detected by the

monitoring, by the micro-controller, of a door or ignition switch. When the appropriate signal is received, the process moves to step 702 at which the date and time contained in the GPS data is logged in the memory 402. Next the process moves to steps 703 and 704 at which the absolute latitude and longitude data is logged in the memory 402. From step 704, the process moves to step 705 where the process enters a wait state. When a stimulus is received, as described above, indicating that further data should be logged then the process moves to step 707 at which the process checks whether the ignition switch is on. If the ignition switch is on this indicates that the journey is continuing and so the process moves to step 708 at which the relative positional data is logged as described above. After step 708, the process returns to step 705 to wait for the next stimulus indicating that data should be logged.

Eventually at step 707 the ignition switch will be detected as being off the process moves to step 709 at which point the stop time along with the absolute position data is stored in the memory 402 and the process returns to step 701.

Referring to Figure 8 herein, there is shown transmission of data in accordance with the preferred embodiment in which real-time positional and time/date data together with optional sensor data are accumulated in the memory records 402 on board the vehicle. The data collection unit 300 accumulates data substantially in real-time until a transmission of accumulated data is triggered. Triggering of the transmission of accumulated data may occur in response to a periodic stimulus, e.g. every hour.

In addition to the transmission of stored real-time data from the memory 402 at the regular periodic transmission intervals, as mentioned above, data may be transmitted under control of the processor from the memory 402 in response to aperiodic events or operations of the vehicle. Such events or operations which occur aperiodically may include events such as opening of the rear doors of the vehicle, a temperature of a vehicle body exceeding a predetermined limit, fuel levels exceeding a

predetermined limit, turning on or turning off the ignition of the vehicle, or other predetermined events measured by sensors attached to the vehicle. Examples of such conditions are shown in Figure 9.

Figure 10 shows the micro controller process when arranged to transmit the stored data at predetermined time interval. At step 1001, the micro controller 403 determines whether the appropriate interval has passed and , if so, then at step 1002 transmits the stored data records via the radio transmitter 405 and data communication antennae 406. Thereafter, control is returned to step 1001.

Figure 11 shows the micro controller process when arranged to transmit data in response to an aperiodic stimulus, such as a sensor signal as mentioned above. At step 1101 the process waits for the stimulus and when such a stimulus is received, moves to step 1002 to transmit stored data from the memory 402 via the radio transmitter 405 and data communication antennae 406.

By transmission of the contents of the memory 402 in accordance with the above conditions, data transmissions can be reduced. Thus, occupancy of communication channels between the vehicles and the base stations may be optimised and the ratio of positional, time and sensor data transmitted in proportion to the protocol overhead of the transmission channel can be improved. It will be appreciated that where there are a large number of moveable objects to be monitored, reduction in the amount of connections and disconnections of communication channels per unit of data transmitted is desirable from a technical point of view in simplifying processing requirements and complexity of equipment.

Referring to Figure 12, there is shown an arrangement of the monitoring apparatus at the monitoring station 205. The apparatus comprises a modem 1201 for receiving data over the public switch telephone network 206 from the control centre 204. The monitoring apparatus further comprises a central processor 1202 for processing received data, a storage device 1203 for storing the received data and map

data, and a user interface 1204 comprising a display device in the form of a monitor, a keyboard entry device, and a pointing device.

Claims

1. A method of monitoring a geographically moveable object comprising the steps of;

substantially continuously receiving geographic position data at said geographically moveable object;

recording a first set of data representing the absolute geographic position of said object at a first position; and

recording a second set of position data representing a second position of said object relative to said first position.

2. A method according to claim 1 further comprising the step of recording subsequent sets of relative position data representing subsequent positions of said object relative to the immediately preceding recorded position.

3. A method according to any preceding claim in which said absolute position data comprises two n-bit words and said relative position data comprises a one n-bit word.

4. A method according to claim 3 in which n = 22.

5. A method according to any preceding claim in which said relative position data is created from the difference between the absolute position data of a given position and the position data of the immediately preceding recorded position.

6. A method according to any one of the preceding claims, further comprising the step of recording a corresponding time/date data associated with said position data.

7. A method according to any preceding claim, wherein said position data is recorded at intervals ranging from 30 seconds to 30 minutes.

8. A method according to any preceding claims, wherein said position data is stored at intervals ranging from 2 minutes to 10 minutes.

9. A method according to any preceding claim, wherein the movable object is a vehicle and recording of said data is initiated by the vehicle ignition being activated.

10. A method according to any preceding claim, in which a further set of data representing the absolute geographic position of said object is recorded in response to the movement of the vehicle ceasing.

11. A method according to any preceding claim in which further data is recorded in response to operational events of said movable object, said data representing said operational event.

12. A method according to claim 11, in which position data is recorded in association the operational event data, said position data representing the geographical position at which said event occurred.

13. A method according to any preceding claim, further comprising the step of transmitting said recorded data to a base station to provide a history of the movement of said object at said base station.

14. A method according to claim 13, wherein said recorded positional data is transmitted in response to a periodic or an aperiodic signal.

15. A method according to claim 13 or claim 14, in which said step of transmitting said position data is activated in response to a signal generated in response to an operation of said moveable object.

16. A method according to any of claims 13 to 15, wherein said step of transmitting is activated in response to a received interrogation signal.

17. A method according to any of claims 13 to 16, wherein said transmission of data from said geographically moveable object commences in response to a received geographical position data.

18. A method according to any of claims 13 to 17, in which the transmitting of said recorded data is performed at predetermined time intervals.

19. A method according to any of claims 13 to 18, wherein the transmitting of recorded data is performed over an open radio channel.

20. A method according to any of claims 13 to 19, wherein the transmitting position data comprises transmission over a Global System for Mobile Communications (GSM) channel.

21. A method according to any preceding claim in which said geographic position data is data created by a Geographic Positioning System (GPS).

22. An apparatus for monitoring a geographically moveable object comprising;

means for substantially continuously receiving geographic position data at said geographically moveable object;

means for recording a first set of data representing the absolute geographic position of said object at a first position; and

means for recording a second set of position data representing a second position of said object relative to said first position.

23. An apparatus according to claim 22 further comprising means for recording subsequent sets of relative position data representing subsequent positions of said object relative to the immediately preceding recorded position.

24. An apparatus according to claims 22 or 23, in which said absolute position data comprises two n-bit words and said relative position data comprises a one n-bit word.

25. An apparatus according to claim 24 in which n = 22.

26. An apparatus according to any preceding claim in which said relative position data is created from the difference between the absolute position data of a given position and the position data of the immediately preceding recorded position.

27. An apparatus according to any one of claims 22 to 26, further comprising means for recording a corresponding time/date data associated with said position data.

28. An apparatus according to any of claims 22 to 25, arranged to record said position data at intervals ranging from 30 seconds to 30 minutes.

29. An apparatus according to any of claims 22 to 28, arranged to record said position data at intervals ranging from 2 minutes to 10 minutes.

30. An apparatus according to any of claims 22 to 29, wherein the movable object is a vehicle and recording of said data is initiated by the vehicle ignition being activated.

31. An apparatus according to any of claims 22 to 30, arranged to record a further set of data, representing the absolute geographic position of said object, in response to the movement of the vehicle ceasing.

32. An apparatus according to any preceding claim in which further data is recorded in response to operational events of said movable object, said data representing said operational event.

33. An apparatus according to claim 32, in which position data is recorded in association the operational event data, said position data representing the geographical position at which said event occurred.

34. An apparatus according to any of claims 22 to 33, further comprising means for transmitting said recorded data to a base station to provide a history of the movement of said object at said base station.

35. An apparatus according to claim 34, wherein said transmitting means is operable to transmit recorded positional data in response to a periodic or an aperiodic signal.

36. An apparatus according to claim 34 or claim 35, in which said transmitting means is operable to transmit said position data in response to a signal generated as a result of an operation of said moveable object.

37. An apparatus according to any of claims 34 to 36, wherein said transmitting means is operable to transmit said data in response to a received interrogation signal.

38. An apparatus according to any of claims 34 to 37, wherein said transmitting means is operable to transmit said data in response to a received geographical position data.

39. An apparatus according to any of claims 34 to 38, in which the transmitting means transmits said data at predetermined time intervals.

40. An apparatus according to any of claims 34 to 39, wherein the transmitting means utilises an open radio channel to transmit said data.

41. An apparatus according to any of claims 34 to 40, wherein the transmitting means utilises a Global System for Mobile Communications (GSM) channel to transmit said data.

42. An apparatus according to any of claims 34 to 41, in which said geographic position data is data created by a Geographic Positioning System (GPS).

42. An apparatus according to any of claims 34 to 41, in which said geographic position data is data created by a Geographic Positioning System (GPS).

43. An apparatus for monitoring a geographically moveable object as described herein with reference to figures 1 to 12.

44. A method for monitoring a geographically moveable object as described herein with reference to figures 1 to 12.

The Patent Office

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Application No:	GB 9719619.0	**Examiner:**	Dr E P Plummer
Claims searched:	all	**Date of search:**	23 February 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4D (DAB, DPBC)

Int Cl (Ed.6): G01S

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US5251078 SONY	
A	WPI accession no. 96-001806 & JP070260920 (ICOM)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.